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INFRA-RED SPECTROSCOPY[1]

SIR WILLIAM HERSCHEL is generally credited with having first demonstrated the presence of an infra-red spectrum. His experimental procedure, as reported under the date of April 24, 1800, in the Philosophical Transactions of the Royal Society, was simple and effective. A prism resolved a beam of sunlight passing through a slit in a shutter into a spectrum which fell upon a table. By placing in the region beyond the red end of the spectrum the blackened bulb of a thermometer, he found that it registered a rise in temperature: an even greater rise in temperature than occurred when the bulb was inserted in the red band of the spectrum. As the bulb was moved outward from the red end of the spectrum, this effect was found to reach a maximum and then to diminish rapidly to zero. Since the thermometer also registered a rise in temperature when placed in any one of the seven colored bands into which Newton had divided the spectrum, the question arose as to whether the visible spectrum consisted of a single radiation which produced both illumination and heat, when received upon solid surfaces, or of two distinct agencies, one resulting in illumination and one in heat effects. His statement of the problem is so admirable that I quote it in its entirety:

> . . . if we call light, those rays which illuminate objects, and radiant heat, those which heat bodies, it may be inquired, whether light be essentially different from radiant heat? In answer to which I would suggest, that we are not allowed, by the rules of philosophizing, to admit two different causes to explain certain effects, if they may be accounted for by one. A beam of radiant heat, emanating from the sun, consists of rays that are differently refrangible. The range of their extent, when dispersed by a prism, begins at violet-colored light, where they are most refracted, and have the least efficacy. We have traced these calorific rays throughout the whole extent of the prismatic spectrum: and found their power increasing, while their refrangibility was lessened, as far as to the confines of red-colored light. But their diminishing refrangibility, and increasing power, did not stop here: for we have pursued them a considerable way beyond the prismatic spectrum, into an invisible state, still exerting their increasing energy, with a decrease of refrangibility up to the maximum of their power: and have also traced them to that state

[1] Address of the Vice-president and Chairman of Section B, Physics, American Association for the Advancement of Science, Philadelphia, 1926.

where, though still less refracted, their energy, on account, we may suppose, of their now failing density, decreased pretty fast: after which the invisible *thermometrical spectrum*, if I may so call it, soon vanished. . . .

If this be a true account of solar heat, for the support of which I appeal to my experiments, it remains only for us to admit, that such of the rays of the sun as have the refrangibility of those which are contained in the prismatic spectrum, by the construction of the organs of sight, are admitted, under the appearance of light and colors: and that the rest, being stopped in the coats and humors of the eye, act upon them, as they are known to do upon all the other parts of our body, by occasioning a sensation of heat.

In spite of this altogether correct point of view, Sir William finally came to the conclusion that there were two kinds of radiation involved. This was because, starting from the extreme end of the invisible region, he found that the intensity, as measured by a thermometer, rose to a maximum and began to fall before the red of the visible became evident, that the heat spectrum continued to fall steadily towards a zero value at the violet end, while the light spectrum increased in intensity to a maximum in the yellow-green region before falling to the same limit at the violet end. He states the case as follows:

. . . it appears that those who would have the rays of heat also to do the office of light, must be obliged to maintain the following arbitrary and revolting positions: namely, that a set of rays conveying heat should all at once, in a certain part of the spectrum, begin to give a small degree of light: that this newly acquired power of illumination should increase, while the power of heating is on the decline: that when the illuminating principle is come to a maximum, it should, in its turn, also decline very rapidly, and vanish at the same time with the power of heating. How can effects that are so opposite be ascribed to the same cause? 'First of all, heat without light: next to this, decreasing heat, but increasing light: then again, decreasing heat and decreasing light. What modification can we suppose to be superadded to the heat-making power, that will produce such inconsistent results?

This dual idea of Herschel's had other confirming evidences not so important in themselves but which when taken together strengthened his belief that there were two agencies active, one producing heat, the other light. Herschel's ideas appear to have been generally adopted, though Melloni stated in 1843 that light was "merely a series of calorific indications sensible to the organs of sight and, vice versa, the radiations of obscure heat are veritable invisible radiations of light," a statement which Langley called "the foresight of a man of genius." It was not until Langley's work appeared that the last traces of these ideas disappeared and a single radiation spectrum emerged continuous from the extreme ultra-violet to the end of the infra-red.

Before Langley began his work in 1880 infra-red data were in a somewhat chaotic state. Only by means of prisms could the energy be sufficiently conserved to permit measurements in this region with the detecting systems then available, but these prism spectra were very unsatisfactory since the small refrangibility of these radiations resulted in the entire infra-red field being condensed in a very small space. There was, moreover, no way of translating prism deviations into wave-lengths. Dispersion formulae good in the visible region, gave very discordant results when extrapolated into the infra-red, some, in fact, limiting the possible infra-red spectra produced by prisms to 1 μ. Capt. Abney's photographic results extending to 1.6 μ were questioned on this basis.

Langley's interest in solar radiation led him to attack the problem of infra-red spectra. He felt that his long employment of the thermopile in studying solar radiation might be of assistance to him in the new field. How well justified he was in these expectations, the record of his achievements in this work amply testifies. It is very seldom that a single investigator in a comparatively short period is able to advance an extensive field of research from a state which is largely qualitative to such a high state of quantitative development that a period of forty years does not produce fundamental changes in methods. In the field of the near infra-red, both prism and grating spectra are measured to-day much as Langley measured them. The results of present-day researches in this region are superior to Langley's mainly because time has brought refinements to the methods used by Langley, not because anything radically new had been discovered. Of the new experimental tools and methods employed by Langley the bolometer probably ranks first. With it he was for the first time able to measure the energy of a linear region of the spectrum. It possessed such sensitivity that it could be used to measure even the relatively weak grating spectra, and thereby make possible for the first time the accurate measurement of infra-red wave lengths. This in turn made possible the transformation of prism spectra into normal spectra. He was then able to show that energy curves for the radiations from blackened surfaces at various moderate temperatures showed a shift of their maxima towards shorter wave lengths as the temperature of the sources rose, a relation which developed later in the case of black-body radiation into Wien's displacement law. In these results and in many others of equal importance, the effectiveness of the bolometer was supplemented by other important improvements. The galvanometers were bettered until the later ones

showed an increase in sensitivity of ten thousand times the ones first used and were at the same time less erratic. Rock salt prisms and lenses were for the first time given high optical surfaces, capable of producing results in all respects equal to those obtained when glass was used.

To reduce the tediousness of the observations, automatic registration was devised, and methods developed for translating into normal line spectra the bolometric curves obtained from the prism spectrometer. Thus to map out the infra-red solar spectrum was one of the principal aims of Langley's infra-red researches. He succeeded in mapping out the absorption spectrum of the sun as far as 5 μ. The first portion of this spectrum was composed of fine lines which were followed in the longer wave-length portion by bands. These latter were correctly attributed to the water-vapor and carbon dioxide of the air. The lines of this spectrum can not now be identified with the lines of the spectra of any of the many elements which have since been measured. This is probably due to the difficulties arising from Langley's use of a salt prism as a dispersing medium. If a knowledge of the infra-red spectrum of the sun should ever be necessary, it would have to be remeasured by the means and methods now available. This carefully and laboriously measured spectrum has suffered a fate similar to that of many other pieces of work which were intended to be final. In Langley's case as in that of others the methods developed have been the important contributions. They have remained to this day the most effective in general use.

To one interested in exact measurements in this spectral region, the work of Paschen will always stand out as having contributed those refinements of apparatus and methods which were necessary to make infra-red measurements an integral part of spectroscopic data. These data are now used with the same confidence as data from other portions of the spectrum in the development of spectral theories. Paschen's improvements consisted primarily in replacing the bolometer by a linear thermopile which, while not quite so sensitive, was rapid and certain in action and free from many of the defects inherent in bolometers; in improving the galvanometer by increasing both its sensitivity and steadiness and in developing a type of grating spectrograph which preserved the maximum accuracy of grating measurements and was at the same time simple in operation and equally effective throughout the spectrum.

While Paschen made extensive researches in other phases of the infra-red problem, the work of particular interest here is the work on the emission spectra of the elements. It revealed for the first time the full possibilities of infra-red measurement with grating spectrographs, combining as they do maximum dispersion and great accuracy of measurement. His first results went far toward establishing the combination principle of Ritz, since many of the combination lines predicted by Ritz lay in the near infra-red region. With sources of constant intensity an accuracy of one unit in the sixth significant figure was possible in the region from 10,000 to 30,000 Å; with unsteady sources, as open arcs, one unit in the fifth place; while beyond this, a few units in the fifth place to as far as 5 μ. The numerous emission spectra measured by Paschen in the near infra-red region contributed very materially to that extensive development of the series relations which will always be associated with Paschen's name.

Among the new series whose discovery resulted from these infra-red measurements of Paschen and his students are the well-known Paschen infra-red hydrogen series, the Bergmann or Fundamental series for many elements, the principal series of triplets for Zn, Cd, Hg, Mg, Ca, of doublets for aluminum and thallium, the material development of the single line series of Zn, Cd and Hg. In addition, the lines of the first terms of numerous series were found and accurately measured. Standard wave lengths in Hg, Zn and Cd were established.

It is of interest to note that a number of strong combination lines lying between 4 μ and 9 μ, accurately located by combining terms determined by grating measurements, were verified by Paschen and the writer in 1910, using a fluorite spectrograph, the longest of these lines being the 3 d–3 p lines of Na, lying somewhat beyond 9 μ. This is the longest wave length measured up to the present time in emission lines. It is particularly to be desired that other strong combination lines, lying still farther out, be measured since the extension of exact measurement into the far infra-red region requires accurately measured lines for use as standards in calibrations. In his report at Brussels in 1910 to the International Congress of Radiology, Paschen lists some fourteen such lines extending from 9 μ to 33 μ which he considered should be strong lines. The present rules governing the intensities of lines also require these lines to appear with great intensity.

In recent years nearly all, if not all, of the work involving high dispersion and high accuracy of measurement in the near infra-red has been done in America. In the field of line spectra it is now possible to remeasure the emission spectra of many elements and find from two to five times as many lines as were first found. This increased effectiveness is due in part to more sensitive thermopiles and improved radiometers. The principal reason for this advance,

however, is the use of echelette gratings and sources of much greater energy.

Accordingly, the speaker and several of his students have remeasured the near infra-red spectra of Ba, Sr, Zn, Cd and Pb with the result that the additional data secured have materially contributed to the completion of the known series relations of the first four of these elements and are contributing towards the establishment of the relations of Pb which are not yet well developed. The earlier work of Randall and Barker on the emission spectra of Fe, Ni, Co, Cr and Mn has recently proven of distinct value in developing the multiplet groups distinguishing the series of these elements.

Recent developments in spectroscopic theory determine the intensities of lines as well as their wavelengths. It has become necessary, therefore, to find accurate methods of measuring these intensities. Without doubt the simplest and also most direct means of determining the intensities of the lines of a multiplet group is that employed in these infra-red measurements where the intensity of a line is taken to be directly proportional to its heating effect, and ultimately to a galvanometer or radiometer deflection. The only requirements are that the lines have sufficient, but not too great, separations and that the source be one of constant intensity.

To a teacher engaged as the speaker was in presenting to a class Nernst's attempt to explain the temperature variation of the molecular heats of polyatomic gases by applying the quantum theory to the rotations of molecules, the appearance in 1913 of Eva von Bahr's work on the absorption of HCl gas at 3.5 μ was most opportune, since the fine structure into which this band was partly resolved seemed to be experimental evidence of the most direct kind that molecular rotations were capable of quantization, a state of affairs difficult to accept at that time even if quantization involving definite frequencies were acceptable. Being engaged at the same time in the measurement of infra-red emission spectra of the elements by means of a grating spectrograph, it was most natural to apply this means of obtaining the necessary high dispersion to the problem of the further resolution of this band into its fine structure, avoiding overlapping spectra, however, by preceding the grating spectrograph by a prism spectrograph of small dispersion. The first work was carried on by graduate students and consisted in examining both the water vapor bands and HCl bands. The water bands analyzed by Sleator proved very complex and too difficult to interpret satisfactorily, but the HCl bands as well as those of other hydrogen halides analyzed by Imes revealed in a striking manner the linear structure of these bands. The lines were narrow, well-separated and of marked symmetry of form and regularity of spacing. As subsequent theoretical development has shown, this resolution was possible because of the small moment of inertia involved and because of the exceptionally simple band structure, for HCl, possessing only two degrees of freedom of rotation, the character of its motion is very much restricted and a single quantum number is required. It is further significant that the change in electric moment with vibrational transition for this molecule is large, which permits intense absorption. The importance of this simplicity of structure of the hydrogen halide bands in the development of theoretical interpretation can hardly be overestimated. The water vapor bands, because of their complexity, have thus far contributed very little to this development, although their fine structure had been observed in detail before that of HCl. It should be remarked in this connection that shortly preceding this, Kemble and Brinsmade had obtained a very good analysis of the HCl band at 3.5μ, using a prism spectrograph instead of a grating.

The HCl spectrum as observed by Imes yielded one other item of exceptional interest, namely, the isotope effect which appears on account of the differences in vibration frequency for molecules in which the Cl atom has different masses. This is the earliest indication of the isotope effect in spectra. With the completion of these first researches in this field, other members of the staff became interested in the problem, and it should be said that most of the subsequent developments of this field of research at Michigan are to be placed to their credit.

Bands which the maximum dispersion of single prism spectrographs had shown as single, or at the most double, have since been resolved into ten, twenty or even forty narrow lines whose wave lengths are measurable with approximately the same accuracy as the lines of an emission spectrum of an element, *e.g.*, within a few Å units. The positions of these bands in the spectrum are assumed to be determined by the energy changes attending transitions between possible vibrational states of the atoms in the molecule while the fine line structure is due in a corresponding way to changes in the rotational states of the molecules. These bands are for the most part associated with changes of the nuclear motions only and their origin is thus simpler than that of bands in the photographic regions, which involve, in addition, electronic transitions. Moreover, since we are here dealing with absorption by unexcited molecules we are certain that these transitions originate in the normal state. The experimental investigation of such spectra, if it can be sufficiently extensive and exact, forms therefore an approach to the study of the positions of the

atomic nuclei and their mutual reactions which is certain to give results of great value to the theoretician who has need of simple systems to serve as first tests of his results. The oscillator and rotator are perhaps the two simplest possible systems.

As an example of this, the single missing line in the HCl spectrum was always an indication that the older quantum theory was incorrect. Its absence, on the other hand, has been one of the means of verifying the new theories of Heisenberg and Schrödinger. Also, these theories as applied to the anharmonic oscillator-rotator by Mensing and Fuess, respectively, show that the apparent vibrational and rotational quantum numbers should be $N+\frac{1}{2}$ and $M+\frac{1}{2}$ instead of n and m. The correctness of these results had already been shown by Colby when he established the fact that the very weak band of HCl due to transitions from the first to second vibrational states could be explained only by using $\frac{1}{2}$ quantum numbers in the Kratzer formulae.

The extension of this method of analysis to infra-red bands of other gases has become possible only with the development of more effective methods of observation. The more complex molecules give bands with smaller separation between individual lines and with less simple structure, so that the analysis requires higher resolution. Also many of the bands lie at greater wave lengths where the available energy is very considerably smaller. The necessary increase in sensitivity has been made possible very largely by the introduction of echelette gratings, and the analysis of fine structure for bands out to 15μ is now progressing. Data yielding detailed information regarding molecular configuration are now available for methane, ammonia, ethylene and carbon dioxide.

An echelette grating is one in which the grooves have a triangular form with smooth sides, ruled deeply enough so that none of the original surface remains. The result is very like a broad staircase in appearance. As mounted in a spectrograph, an incident beam normal to one of the oblique surfaces is reflected upon itself with an intensity much greater than would be produced by an ordinary grating and with a wave length determined by the small path difference from step to step. Gratings of this sort were first described by R. W. Wood (1911), his being ruled upon gold-plated copper sheets, but lacking good optical properties because the surfaces were not flat.

At Michigan, due mainly to the perseverance and skill of Dr. E. F. Barker, it has been possible to develop these gratings to a very satisfactory degree, not only for coarse rulings, but even up to as many as 14,400 lines per inch. The surfaces used are ground and polished to optical flatness—aluminum for the coarse spacings and nickel for the finer ones—and the ruling point is a diamond ground to the proper angle. For the earlier experimental work the laboratory was fortunate in having the original Rowland machine kindly placed at our disposal by the department of physics of Johns Hopkins University. While experiments in ruling were under way our own ruling machine was constructed, the design and assembly being largely the work of Captain A. de Khotinsky. This machine is capable of ruling a surface 10 x 20 inches with lines spaced from 25 up to 14,400 per inch.

In view of the fact that methods are required which are still more sensitive than those at present available even when echelette gratings are used, if bands now impossible of resolution are to be studied, and particularly if the work is to be extended into the far infra-red region, it is desirable to consider what, if anything, may still be done. Accepting the radiometer as recently improved, and the linear thermopile-galvanometer combination in its most sensitive form as the receiving devices, what may be hoped for in this direction? While it is possible that some temperature effect quite different from these may be found, much more sensitive than either, it is probable that the great majority of workers are now trying to increase the readings of these two devices by various schemes of amplification.

The enthusiastic confidence which an engineering friend had in the early days of vacuum tube amplification that it was possible to amplify any E.M.F. until the final circuit could deliver power in horse power units has never been realized. It is soon evident to any one trying to amplify the E.M.F. of a thermopile or its current that there are decided limitations to any kind of amplification of these or any other small effects which may be used to register the feeble radiations under examination. These limitations lie in the fact that in all cases there are present disturbances, usually irregular, of the same order of magnitude as the quantities which it is desired to amplify. Under these circumstances amplification is futile. The problem becomes one of suppressing such chance disturbances. To the extent to which this can be done, amplification by any one of a number of means is possible. If, as a recent writer has claimed, the residual perturbations in an amplification system have their origin in Brownian movement, then there is a definite upper limit to the amplification methods of increasing the sensitivity of receiving devices. At present it appears that there are certain advantages to be gained from moderate amplification. These advantages consist mainly in being able to use more robust instruments, of shorter period and less sensitivity, but with an appreciable gain in resulting sen-

sitivity through amplification. To those accustomed to the use of galvanometers adjusted to the point of unsteadiness in order to secure sensitivity, these are very material gains in themselves since they insure quick action and freedom from the vexations of drift and erratic fluctuations. More important still, it appears possible with such systems to devise methods of automatic registration of observational data without that accompanying decrease in sensitivity which formerly was inevitable when galvanometers were made sufficiently steady for registering devices. To be able to record the fine structure of absorption bands automatically, quickly and with no loss of resolution and accuracy will result in shifting the accent in this work from the slow and tedious process of getting data over a comparatively small number of bands to the interpretation of ample data covering an entire system of bands. There is, in other words, the promise here of a revolution in this field of research.

The data obtainable from the near infra-red region should be supplemented, if possible, by data obtained from the far infra-red regions. The near infra-red bands, due as they are to combined vibrational and rotational transitions, suffer perturbations, arising from the mutual reactions of these motions, while in the far infra-red the bands are comparatively free from such perturbations since the molecules are not vibrating, and the rotational transition only is involved. This isolation of the nuclear problem is of particular value in the study of polyatomic molecules, where even the problem of rotation alone may become very complex. The obvious need of such data is resulting in attempts to extend to these regions the methods used so successfully in the near infra-red. The difficulties in the way of such a development are exceedingly great, due mainly to the small amount of energy available and to our inability to isolate the region under investigation. As will be recalled, Rubens and his associates explored this entire region up to 300 μ by a series of brilliant experimental researches among which the discovery of the reststrahlen method of isolation by Rubens and Nichols and the focal isolation method by Rubens and Wood are most prominent. Once isolated these narrow spectral regions were analyzed roughly by the aid of interferometer curves or by coarse wire gratings. If greater dispersion is to be used in this region in an endeavor to reveal the structure of the rotational bands it is evident that the minute amount of energy here available must be conserved to the maximum extent. This at once suggests the use of echelette gratings for the dispersion agent. As a matter of fact the speaker several years ago obtained data extending to 50 μ from gratings of this sort which indicated that they could be used effectively throughout this region. The problem of making such gratings is quite different from the earlier one of making gratings to use in the near infra-red region, since the coarseness of the gratings requires the cutting out of the grooves by steel tools. This means that a very soft metal must be used. At present thin solder surfaces on light aluminum forms are being tried out. This material can not be ground flat so the ruling engine is first used as a shaper, planing a surface as smooth as possible on the solder. Then without moving it, the surface is ruled. To date, only a few coarse gratings of this kind have been ruled. They are being used in an attempt to find and measure the combination lines of aluminum, thallium and lithium, which, as Paschen predicted, should lie in the region between 15 and 33 μ.

So far we have been concerned chiefly with the accomplished facts of experimental and theoretical research in the infra-red region. In conclusion we may be permitted to outline some of the problems of this field of research which are pressing, and to anticipate some of the possibilities which await improvements in technique that appear to be fairly certain of attainment.

In the field of line spectra there is a pressing need for measurements in the infra-red spectrum of those elements whose series relations are now being developed. As already mentioned the possibilities of infra-red methods when applied to the measurement of intensities should be thoroughly tested. When improved technique permits, those weaker sources which give characteristic spectra should be examined. There is finally always the immense field of the far infra-red wholly unexplored as far as line spectra are concerned. Possibly the radiations from the quartz mercury vapor lamp near 300 μ, discovered by Rubens and von Baeyer, is of this type. In any case its structure should be discovered and its origin determined.

In the field of band spectra there are some very obvious advances which await the development of experimental technique. With the increased resolution which will follow increased sensitivity, the fine structure may be determined for a large number of bands which now just escape us. This is particularly promising in the study of polyatomic molecules, at least for those with an approximate axial symmetry. The new wave mechanics of Heisenberg and Schrödinger give us for the first time satisfactory expressions for intensities. Considerable progress has already been made in the study of the symmetrical rotator and, with the slight experimental data now at hand, gives great promise. The Heisenberg theory gives two alternatives between which it can not decide for the quantum numbers describing the rotation. They may be either integral or half quantum numbers. By the Schrödinger theory they should be whole numbers.

No decisive data for symmetrical molecules is now available, but it appears that the measurement of the infra-red absorption spectra of such molecules might be decisive. There is no doubt that a more careful study of intensities must be made, a rather exacting problem where the fine structure is not easily resolved. Such measurements should not only yield information concerning the molecule in question but also serve as tests for certain details of the wave mechanics itself.

Not only are the intensities important, but also the shape and breadth of the lines have theoretical significance. This phase of the subject is but slightly developed and so far agreement with experiment is not good.

Bands in the far infra-red can not be expected from molecules which have no permanent electric moment. This probably excludes such a molecule as methane, whose rotation is by no means clearly understood. There is, however, a large number of gases for which data in this region will be invaluable. The problem of normalization of the rotation of HCl has been definitely settled by its far infra-red band. Water vapor has a far infra-red absorption spectrum, the intricacy of which must be ascribed to its lack of symmetry and has not been satisfactorily interpreted. Symmetrical rotation should be investigated here as soon as possible. The most promising for this purpose is the ammonia molecule.

The infra-red region is not simply an extension of the spectrum at the long wave-length end. The data which it furnishes are not simply more data of the kind to be obtained in the other parts of the spectrum. The band spectra of the near infra-red region are different in type from those of the far infra-red and both are different in character from the bands in the photographic regions. The information to be obtained from these infra-red spectra is not to be found elsewhere. Their resolution and measurement is therefore a problem not only worthy of our endeavor but necessary for the development of the theories of band spectra and the related problems of molecular structure.

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SCIENTIFIC SERVICE THAT THE NATIONAL FORESTS MIGHT BE RENDERING

WITH the network of good roads that has been constructed within the last few years rapidly extending itself over every part of this country, scientific men and nature lovers are faced by the fact that we shall soon have no wild places and no areas left in their natural condition except barren and inaccessible mountain tops and waterless deserts, unless reservations are set aside for preserving the natural conditions.

In fact, at the present time the only places of any considerable extent that are intended to be kept in a natural state are the national parks, and as time goes on these are being managed more and more as recreation resorts, their natural condition being sacrificed to the entertaining of large crowds of tourists. The destruction of timber in building and grading the broad roads for high-speed traffic, the wear and tear caused by the tens of thousands of visitors in the places most famous for their scenery, the camps, hotels, garages, etc., necessary to serve and accommodate them, the parking of thousands of cars and other accompaniments of the constantly growing tourist traffic are disastrous to the natural conditions in those regions of the parks where the scenery is most remarkable, while those regions of them that lie off the routes of tourist travel are not safe from destructive exploitation legalized by acts of Congress slipped through without the public understanding their purpose or effect. Not a session of Congress passes without attempts to trim off portions of the parks containing timber or other commercially valuable resources, and too often they are successful. Three of the national parks have been treated this way during the past year (1926). From state and local parks we have little to hope in the way of preserving natural conditions. They are usually too small and are commonly managed chiefly as recreation resorts; moreover, they always suffer under the frequent changes of administration that occur in local governments.

If natural conditions are to be preserved it must be accomplished in places that are not resorted to by crowds of tourists, a condition that the national parks with their wonderful scenery can not meet. Also it is usually necessary that the reservations should be of some extent in order that the destructive effects of exploitation on adjacent lands may not reach completely over them. Land used for grazing, and least of all land used in forestry operations, as is the case with the national forests, does not remain in a natural condition, though it may serve well enough as a preserve for the protection of birds or animals that can adapt themselves to the changed conditions. It is especially the very old trees that have taken centuries to grow and would take centuries to restore, that make the difference both from a scenic and scientific point of view between a primeval forest and an ordinary farmer's wood lot or the young growth of cut over lands.

This leads us to wonder why a few square miles out of the immense extent of the national forests

(whose total is given as 157,502,793 acres) have never been permanently set aside as reservations to be kept in their natural condition for scientific purposes and for exemplifying the different types of forest in their most perfect development.

It would naturally be expected that the selection for permanent preservation for scientific and scenic purposes of the finest tracts of each of the various different ecological types of forest would be one of the first steps of a scientifically conducted bureau on assuming the management of the nation's forests. Probably there is a general belief that it is being done, but if any such reservations had been made we would certainly find notice of them in the recently published "Naturalist's Guide to the Americas" of the Ecological Society of America, a work in which several forest service officials cooperated, and which must give an official expression of the policy of that bureau. We may look in vain in it for any information of the existence of such reservations; on the other hand, we find in an article in it entitled "Permanent Sample Plots in the National Forests," by C. F. Korstian, of the United States Forest Service, the following statements:

> Relatively few of the permanent sample plots on the National Forests are in virgin forest and the silviculturist can not imagine keeping all of them in such a condition, even if they are now. . . .
>
> Since the silviculturist is working in part on such utilitarian problems as the effects of different methods of cutting or thinning or slash disposal on the subsequent growth of the uncut trees and on natural regeneration, the reason why his permanent sample plots must be located largely outside of virgin forest is apparent. As a matter of fact most of these plots are on culled or cutover lands where the conditions are at most only semi-natural. . . .
>
> It is therefore evident that the permanent sample plots in the National Forests, although they may not all be important from the standpoint of the preservation of natural conditions, will supply the forester, the ecologist and the biologist with much valuable scientific information which can not be secured in any other way.[1]

Nobody will dispute the importance of such plots for experimental purposes, but they do not preserve natural conditions. The failure of the forest service to set aside plots for the latter purposes has not escaped comment.

Dr. Charles C. Adams, in speaking of the administrations of the national forests, says:

> We see that the ecological conditions in forests are thus undergoing profound changes from wild and primeval conditions and there are almost no parts remaining in these areas which will remain wild unless a new and definite policy is developed of holding as reserves certain areas. There are however many reasons for maintaining such areas for study, demonstration and education and for recreational uses, although this idea has not yet received much recognition in forestry.[2]

Forest service officials themselves admit this. Writing on the same subject G. A. Pearson says:

> It does not assure that any areas will be kept in a natural state unless specific provision is made to attain that end. It is true that extensive areas, because of inaccessibility, will remain comparatively immune from exploitation for many years: but this is merely a temporary condition which unforeseen developments may terminate at any time. The only way in which the preservation of natural conditions can be assured is by formal withdrawal of specific areas under specific provisions as to future care.[3]

Where is the forest service withdrawing from exploitation any such areas? We can not shut our eyes to the fact that even the most conservative forestry operations do not maintain and can not restore natural conditions either from their scenic or scientific aspect. Forestry for commercial purposes will not permit of letting trees grow old or large; generally they will be cut as soon as they will make a small board. If we are to have any sample tracts of the wonderful forests of the Pacific states, which are unequaled anywhere else in the world, no time can be lost in making reservations of them. The first-class timber in the national forests has already been mostly sold off.

Where are there any fine tracts exemplifying the characteristic Douglas fir, western hemlock and cedar forest that formerly covered hundreds of square miles in the northwest with trees 180 to 230 feet tall or over, that are safe from eventual destruction? The firs in such forests are six or seven centuries old or more, the cedars doubtless very much older. There is no forest of that type of any account in any national park except one or two small strips, sadly mutilated by the roads that run through them, and by cutting of firewood for the hotels, in the Mount Rainier Park. Where is any tract of the wonderfully impressive and scientifically interesting Sitka spruce forest that was characteristic of the coastal regions of Oregon and Washington that is being preserved? There is none in any national park.

In asking the forest service to preserve a few square miles of the finest parts of the national forests the scientific men of this country would not be asking for any economic sacrifice. Since a forest in its natural state maintains itself unimpaired, the indi-

[1] C. F. Korstian in "Naturalist's Guide to the Americas," pp. 19–20.

[2] *Scientific Monthly*, XX, June, 1925, p. 585.

[3] *Ecology*, III, October, 1922, p. 285.

vidual old trees that from time to time die off being constantly replaced, any timber so reserved would always be available in a serious national emergency such as a prolonged war. If it is sold and cut for lumber there will be nothing there for a long period to come except a growth of young saplings.

This is not a matter admitting of much more postponement if anything worth while is to be done. Every year of delay makes it more difficult and leaves in the national forests smaller and poorer areas available for reservations. The first-class timber on the public lands is rapidly disappearing. We must not be deceived by statements of vast areas of "primeval forest," or land that has never been logged, in the public domain. They exist, but they consist for the most part only of small and scrubby trees due to poor or rocky soil, high altitude, insufficient rainfall or other unfavorable factors; timber that the lumbermen will not buy until they can no longer get any that is better.

WILLARD G. VAN NAME

THE AWARD OF THE FIRST CHARLES REID BARNES LIFE MEMBERSHIP OF THE AMERICAN SOCIETY OF PLANT PHYSIOLOGISTS

AT the Kansas City meeting of the American Society of Plant Physiologists, in December, 1925, official action was taken by the society to honor and perpetuate the memory of Charles Reid Barnes, first professor of plant physiology at the University of Chicago, by establishing at each succeeding annual meeting an honorary life membership in the society. To this honor is to be elected each year some member distinguished as an investigator in the field of plant physiology. Those so honored are to be known as the Charles Reid Barnes life members of the American Society of Plant Physiologists. It was felt that such a living memorial to Dr. Barnes is one that he himself would have approved, and that it is a fitting tribute to the man who had perhaps greater spiritual and inspirational influence upon students of plant physiology than any other American worker in that science. A large number of those now engaged in physiological botany trace their spiritual lineage directly to Dr. Barnes or indirectly to him through those who came within his personal influence.

The first Charles Reid Barnes life member was elected at the recent Philadelphia meeting of the society and it is fitting at this time to devote a brief space to the great teacher in whose honor the society has established this life membership, and whose tragic death seventeen years ago was mourned by all who knew him. Barnes was fortunate in having Dr. John M. Coulter as his first instructor in botany, at Hanover College, where he took his first degree in 1877. He worked for a time at Harvard with Asa Gray and began his professorial career at Purdue University in 1882. For 28 years he led an exceptionally energetic life in the field of botany. From 1887 to 1898 he was in charge of the botanical work at the University of Wisconsin, where he built up a very active and vigorous department. In 1898 he joined Professor Coulter at the newly organized University of Chicago, and for twelve years guided the development of plant physiology in that institution.

Dr. Barnes was a teacher with rare gifts; the clearness and precision of his presentation of the subjects he taught has seldom been equalled. He captivated the imagination of his students for the field in which he labored. His cordial friendliness, his frank honesty of opinion, his searching analysis of problems, his keen critical estimation of the work of others, all endeared him to every one who studied under his guidance. The reviews that appeared in the *Botanical Gazette* during the 27 years of his co-editorship of that journal with Professor Coulter, show him to have been the keenest American critic plant physiology ever held. His conception of the science was well in advance of his period.

Those who came under his personal guidance in research found in Barnes a wonderful leader, whose clear and versatile vision enabled him always to suggest productive modes of attack upon all manner of problems. He was a wise counsellor, a splendid administrator, an incisive but ever helpful critic, and always a real friend to his students and colleagues.

His death in 1910 was caused by falling on an icy side-walk near his home, shortly after he had started to go to the university for his usual busy day. He became unconscious, and died a day or two later, on February 24, 1910. Those who knew him are proud to honor his memory. His name should be written high in the annals of the rapidly developing science, to which he gave his best.

After careful consideration of the many names that were proposed, the committee on the award of the first Charles Reid Barnes life membership in the American Society of Plant Physiologists has made the award to Dr. Burton Edward Livingston, professor of plant physiology and director of the Laboratory of Plant Physiology of the Johns Hopkins University and permanent secretary of the American Association for the Advancement of Science.

Dr. Livingston began his work in plant physiology at the University of Michigan in 1895 and the following year became an assistant in that subject, under Professor Frederick C. Newcombe, who had recently

returned from Pfeffer's laboratories in Leipzig. He received the B.S. degree in 1898, taught five different sciences in the high school of Freeport, Ill., for one year, and then went to Chicago, where he became a graduate student and assistant in plant physiology under Dr. Barnes. He was in charge of Barnes's laboratory course at Chicago, from 1899 to 1905, and gave several lecture courses. He received the Ph.D. degree in December, 1901, being the first doctor in plant physiology with Dr. Barnes. His dissertation, published as a book in 1903, is on "The Rôle of Diffusion and Osmotic Pressure in Plants." After leaving Chicago in 1905 he was in charge of soil fertility investigations in the U. S. Bureau of Soils at Washington for a year and prepared, with several assistants, the first analytical studies of toxicity in unproductive soils in the humid regions. In 1906 he became a staff member of the Desert Laboratory of the Carnegie Institution of Washington, at Tucson. He spent the year 1908 in research with Professor von Goebel at Munich and spent some time in Pfeffer's laboratory at Leipzig. He was called to the Johns Hopkins University in 1909, to be professor of plant physiology and became also director of the laboratory of plant physiology there in 1913. Dr. Livingston has exerted a large influence upon the development of ecological physiology through his researches and those of his students and associates, upon transpiration, soil moisture, soil oxygen, the mineral nutrient relations between plants and their environment and the influence of climatic conditions on plants. He has originated several devices which have been very useful in measuring quantitatively the dynamic influence of edaphic and climatic conditions. Chief among these are improved types of atmometers, auto-irrigators for the control of soil moisture conditions, and porous porcelain "soil points" for measuring the water-supplying power of soils in a quantitative manner.

In addition to these activities, Dr. Livingston has been engaged in several editorial enterprises: *Physiological Researches, Botanical Abstracts, Plant Physiology* and *Palladin's Plant Physiology,* which has reached three editions in the English translation. He was the first editor-in-chief of *Botanical Abstracts* and contributed much toward getting that journal started. He has been permanent secretary of the American Association for the Advancement of Science since 1920.

Appreciating his long and varied services, the undersigned committee is happy to announce the award to Dr. Livingston, *honoris causa,* of the first Charles Reid Barnes Life Membership of the American Society of Plant Physiologists. This award is the first in the chain of a living memorial to Dr. Barnes, whose memory is revered by all who knew him and should be perpetuated as long as plant physiology remains in the service of mankind.

The Committee on the Award of the first Charles Reid Barnes Life Membership of the American Society of Plant Physiologists:

R. P. HIBBARD
A. E. MURNEEK
F. E. LLOYD
G. W. SCARTH
C. A. SHULL, *chairman.*

SCIENTIFIC EVENTS

EXPERIMENTAL CYTOLOGY AT THE TENTH INTERNATIONAL CONGRESS OF ZOOLOGISTS AT BUDAPEST

THE ninth International Congress of Zoologists, which was held in March, 1913, at Monaco, decided to have its tenth session in 1916 at Budapest, under the chairmanship of the undersigned. War conditions made it unfortunately impossible to adhere to the date determined upon for 1916 and the session of the tenth congress had to be postponed. The present international situation, however, now permits of this congress being held next year.

I have the honor, therefore, with the approval of the permanent committee of the International Congress of Zoologists, to announce that its tenth congress will be held at Budapest from the 4th to 9th of September, 1927, inclusive, and that all zoologists and friends of zoology are most cordially invited to attend.

In addition to the sections already represented at past congresses, a section for experimental cytology will be inaugurated at this time.

The complete program of the congress will be issued during the course of the year and sent to all those interested.

DR. G. HORVÁTH,
President Tenth International Congress of Zoologists.
Hungarian National Museum,
Budapest, September 4, 1926.

A few additional remarks concerning the next to last paragraph of the above announcement are necessary:

The new section for experimental cytology came into existence in the following way: Professor G. Levi, of Turin, and Professor Rhoda Erdmann, of Berlin-Wilmersdorf, were desirous of meeting with other cytologists, from Europe and elsewhere, so that this newly-created special branch might correlate its discoveries with those of the older branches.

This new section for experimental cytology is composed of investigators who already belong to other scientific societies, but who are particularly engaged in experimental cytology. They are founding no new society, but have instead chosen this way of becoming associated with the International Congress of Zoologists as a section, in order to make possible an understanding of the aims, discoveries and methods of experimental cytology. This was made possible by the cooperation of the president of the tenth congress, Professor von Horváth, and the chairman of the Budapest local committee, Professor von Lenhossék.

Invitations to join the sessions of the section for experimental cytology follow, together with that to the Tenth International Congress of Zoologists. They are directed not only to those investigators who are engaged in tissue culture, but to all cytologists who have busied themselves over metazoan, metaphytic and protozoan cells and have studied these either by methods of vital staining, microdissection and tissue culture and have by these means come to any conclusions concerning living cells.

The tentative program for the session of the Tenth International Congress of Zoologists, at Budapest, in 1927, is as follows—the subjects of the lectures are merely outlined:

September 3, Saturday: Social evening of welcome.

September 4, Sunday: Opening session.

September 5, Monday. (Morning.) Joint session of section on experimental cytology with all the sections. Lecture by Professor R. G. Harrison, New Haven, "On the Status and Significance of Tissue Culture."

Afternoon. Special session of section on experimental cytology. Lecture on "The Behavior of Plant Cells in Vitro and in Vivo," by Professor E. Küster, Giessen. Other lectures on similar topics; discussion. Demonstrations particularly desirable.

Sessions of the Section on Experimental Cytology:

September 6, Tuesday. (Morning.) Session opened by Professor G. Levi, Turin: "The Structural Behavior of Living Tissues under Culture." Other lectures on similar topics.

Afternoon. Session opened by Dr. Alexis Carrel, New York: "Modern Techniques of Tissue Culture and Results." Other lectures on similar, or associated topics. Discussion and demonstrations.

September 7, Wednesday. (Morning.) Session opened by Professor Rhoda Erdmann, Berlin-Wilmersdorf; and Professor A. A. Krontowski, Kief: "What has Tissue Culture accomplished toward the Solution of Problems in Pathology, particularly those of Cancer and Immunization?" Other lectures on similar topics.

Afternoon. Session opened by Professor N. Chlopin, Leningrad, and Professor A. Timofejewsky, Tomsk: "The Origin of Blood, Connective Tissue and Related Cell Types." Other lectures on similar subjects, with discussions. Demonstrations desirable.

September 8, Thursday. (Morning.) Session opened by Professor von Möllendorf, Kiel: "Vital Staining and Experimental Cytology." Other lectures along similar lines.

Afternoon. Subject: "Microdissection," lecturer not yet chosen. Lectures along similar or related lines; discussion. Demonstrations.

September 9, Friday. Closing session.

September 10, Saturday. Excursion to Plattensee and inauguration of the new biological station in Tihany, on the Plattensee.

September 11, Sunday. Optional joint excursion to Debrecen and the Hortobágyer Steppe.

The lectures will be given in all four official languages of the congress.

Professor Rhoda Erdmann, Berlin-Wilmersdorf, Nassauischestr. 17, II, editor of the *Archiv für experimentelle Zellforschung,* is now receiving announcements of lectures, demonstrations and any suggestions. Other questions, such as the provision of microscopes, the possibility for projection, etc., should be directed to the secretary of the local committees, Privatdozent Dr. L. Karczag, Budapest III, Klinik für innere Medizin, VIII. Ludòvinumgasse 2. Hotel reservations, transportation and passports will be attended to by the local committee, to which direct applications should be made.

MURAL PAINTINGS OF PREHISTORIC ANIMALS AT THE FIELD MUSEUM

A SIX-YEAR program of work on a series of great mural paintings, and modeled groups of prehistoric animal and plant life, to be carried out on a larger scale and in a more complete and systematic manner than has before been attempted, has been inaugurated by the Field Museum, according to an announcement made by D. C. Davies, director of the museum.

Through the generosity of Ernest R. Graham, of Chicago, the hall of historical geology in the museum, which contains fossils showing the life of past ages, is to be enriched by a series of twenty-eight mural paintings in which the animals of the past are to be represented as they appeared in the flesh and among the strange foliage which surrounded them. In recognition of his gift, the trustees of the museum have named the hall the Ernest R. Graham Hall.

Charles R. Knight, of New York, leading artist in the delineation of prehistoric scenes, is in charge of the mural decorations. Fourteen of the twenty-eight paintings will be twenty-five by nine feet and the balance eleven by nine feet, and there will be a number of groups, which will round out the present exhibits of life of past ages.

Mr. Knight will be aided in his work by several assistants. He is now preparing designs and making

other preliminary arrangements preparatory to actual inauguration of the work.

The twenty-eight mural paintings will show the world as it appeared during past geological ages. Each picture will represent typical life and scenery of a geological period. Dinosaurs, three-toed horses, American camels, flying lizards, coral reefs and mammoths and mastodons, all are to be represented, and with them the surroundings amid which they lived.

Supplementing these paintings will be great modeled groups of animals and plants of the past in life size. While these groups will relate chiefly to the earlier geological periods, some later representations will be included.

Dr. B. E. Dahlgren, acting curator of botany of the museum, who has made notable reproductions of plant life in the Stanley Field plant reproduction laboratories, will have charge of this phase of the work. Work has already started on one geological group, which will show part of a forest of the coal period. The strange cryptogamic plants of that day, which formed forests that later became coal, will be shown in life size, and inhabited by life-sized restorations of insects and reptiles of that time.

The entire program is under the supervision of Dr. O. C. Farrington, curator of the department of geology of the museum.

PROPOSED NATIONAL RESEARCH INSTITUTE FOR CHEMICAL EDUCATION

ESTABLISHMENT of a National Research Institute for Chemical Education with an initial endowment of $2,000,000 is planned by the Senate of Chemical Education of the American Chemical Society, according to an announcement by the chairman of the senate, Professor Neil E. Gordon, of the University of Maryland, at the society's national headquarters, Washington, D. C.

The institute would be located at some university which is doing work of a high order in both chemistry and education, but would be organized separately from either of these divisions.

Its sponsors contemplate that it shall be the great meeting place for the chemistry teachers of the world and that it shall enable chemical education to be of greater service to industry. The idea of the institute arose from the needs of this ever-changing science.

Details of the plan have been definitely worked out and will be publicly discussed by the senate at sessions to be held in connection with the society's spring meeting at Richmond, Va., to be held from April 11 to 16. The senate is composed of representatives of education and industry from every state.

The charter, it is planned, will provide for a board of seven trustees, a board of seven scientific advisers, a general director, associate directors to head the departments and research assistants. Five departments, including graduate, undergraduate, industrial, high school and historical, are proposed.

The tentative budget to be presented to the senate calls for the employment of a general director and of five departmental directors at salaries of $10,000 each. Five fellowships of $1,000 each are proposed, and provision is made for extra summer faculty lecturers at an expenditure of $5,000. The estimated cost of the building to be occupied by the institute is $500,000.

PUBLIC LECTURES ON SCIENTIFIC TOPICS

A SERIES of illustrated lectures on important developments and discoveries in various fields of engineering will be given by members of the staff of the Harvard Engineering School during the second half-year. These lectures will be open to the public, and will be given in 110 Pierce Hall on Thursday afternoons, at 4:30 o'clock, as follows:

February 17, *The story of the incandescent lamp,* PROFESSOR H. E. CLIFFORD.

February 24, *Engines for airplanes,* PROFESSOR L. S. MARKS.

March 3, *Explosives and fertilizers from the air,* PROFESSOR GRINNELL JONES.

March 10, *Electric oscillations and radio communication* (with demonstrations), PROFESSOR G. W. PIERCE.

March 17, *The development of steel structures,* PROFESSOR G. F. SWAIN.

March 24, *The world search for metallic ores,* PROFESSOR D. H. MCLAUGHLIN.

March 31, *Supplying half a billion gallons a day of drinking water,* PROFESSOR G. M. FAIR.

April 7, *Floating metals from their ores,* PROFESSOR A. E. WELLS.

April 14, *Utilization of water power,* H. M. TURNER, consulting engineer.

The Chicago Academy of Sciences announces a course of free public lectures during the winter of 1927, at the Assembly Hall on Sundays at 3:30 P. M., in accordance with the following program:

February 6, *Exploration in the Peruvian Andes,* DR. ISAIAH BOWMAN, director of the American Geographical Society.

February 13, *New explorations in Kentucky caves,* RUSSELL T. NEVILLE, Kewanee, Illinois.

February 20, *What mushroom is that?* VERNE O. GRAHAM, principal of Burroughs School.

February 27, *Vegetation and native races of E. Africa,* DR. HOMER L. SHANTZ, head of the department of botany at the University of Illinois.

March 6, *From the Mackenzie to the Yukon,* MRS. LAURIE FRAZEUR, Senn High School.

April 3, *Life secrets of wild flowers,* A. C. PILLSBURY, University of California.

Dr. Hugh Stott Taylor, professor of physical chemistry at Princeton University, gave three public lectures at the Carnegie Institute of Technology on February 7, 8 and 9. His subject was "Absorption and Contact Catalysis," "The Mechanism of Activation at Catalytic Surfaces" and "Photochemistry and Catalysis."

Other public lectures announced for February will include two public discussions by Dr. Robert Williams Wood, professor of experimental physics at Johns Hopkins University, who will talk on "The Optical Excitation of Spectra," February 17 and 18, and three lectures on metallurgical problems to be given by Dr. Cecil H. Desch, director of the department of metallurgy at Sheffield University, England, on February 21, 23 and 24. The subjects of the Desch series will be "The Crystallization of Steel," "Modern Views on Deformation of Metals" and "Diffusion in Solids."

THE JAY BACKUS WOODWORTH GRADUATE SCHOLARSHIP FUND

A FUND of $5,000 is being raised by former students and associates of the late Professor Jay Backus Woodworth, of Harvard University. To date about $1,050 has been collected with the promise of $2,000 more if an additional $2,000 is raised.

The income of this fund will be appropriated from time to time on the recommendation of the department of geology of Harvard University, as a scholarship to some worthy graduate student in geology, preference being given to the highly capable candidate who showed a natural bent for general geology and gave promise of advancing the science, especially if in the fields of glacial geology or seismology.

The committee feels that there are numerous friends and admirers of Professor Woodworth other than those who have already contributed, who would welcome the opportunity to take part in the creation of this fund in his memory, and thereby to stimulate others to do creditable work in geology.

Contributions may be sent to any member of the committee or to the treasurer of Harvard University, designated for the "Jay Backus Woodworth Graduate Scholarship Fund."

CHARLES F. BROOKS, *Acting Chairman,*
RICHARD M. FIELD,
THORNDIKE SAVILLE, *Chairman*
EDWARD WIGGLESWORTH,
T. WAYLAND VAUGHAN

SCIENTIFIC NOTES AND NEWS

DR. CHARLES D. WALCOTT, secretary of the Smithsonian Institution, died on February 9 in the seventy-seventh year of his age.

DR. CHEVALIER JACKSON, professor of bronchoscopy and esophagoscopy at the Jefferson Medical College, has been presented with the $10,000 Philadelphia award, given annually by Edward W. Bok to the person who has done the most to advance the city's interest during the year. Dr. Jackson was given the award for his invention and use of the bronchoscope.

THE degree of doctor of laws was conferred upon Dr. C. Edmund Kells by Tulane University upon the occasion of the presentation to Tulane University of the Charles Edmund Kells dental library and museum on January 19 in the Hutchinson Memorial Building, Tulane University, at which time Dr. Kells completed his fiftieth year of dental service. During this period he has made important contributions to the literature and science of dentistry.

DR. VLADIMIR FORTUNATO, sculptor of the Johns Hopkins University School of Medicine, has been awarded the U. S. Treasury Department gold medal for life-like vaccination models showing types of reactions to smallpox vaccine.

THE Botanical Society of America has elected the following corresponding members: Professor Erwin Baur, of the Agricultural High School, Berlin; Professor Robert Chodat, of the University of Geneva; Dr. L. Cockayne, of New Zealand; Professor V. Grégoire, of the University of Louvain, and Professor W. Johannsen, of the University of Copenhagen.

ACCORDING to the *Bulletin* of the American Mathematical Society, recent elections to the section of mathematics of the Reale Accademia dei Lincei, of Rome, are the following: Professor F. Severi, of the University of Rome, to national membership; Professor G. Scorza, of the University of Naples, to corresponding membership; Professor E. Cartan, of the University of Paris, to foreign membership.

THE Carnegie Hero Fund has awarded a gold medal to Dr. Honoré Vercauteren, roentgenologist, of Ghent, Belgium, who has been partially incapacitated through his devotion to the treatment of victims of occupational accidents.

DR. MAX PLANCK, professor of mathematical physics at the University of Berlin, has retired.

IN connection with the recent meeting of the Geological Society of America in Madison, Wis., Dr. T. C. Chamberlin, emeritus professor of geology at the University of Chicago, now in his eighty-third year, was the guest of honor at a luncheon given by eighty of his students and friends.

JOSEPH MAILLIARD has resigned his position as curator of the department of ornithology and mammalogy of the California Academy of Sciences, to

take effect on February 28. On account of advancing years, Mr. Mailliard felt that the active administrative duties of the department should be placed in younger hands and that he would like to be able to devote more of his time to investigation and study of the birds and mammals of western America. As a recognition of his long and valuable services to the academy the council elected Mr. Mailliard curator emeritus of the department.

DR. A. C. NOE, associate professor of paleobotany in the University of Chicago, was elected chairman for the Chicago area of the Western Society of Engineers at its recent meeting in Chicago.

PROFESSOR MARSTON T. BOGERT, of the department of chemistry, Columbia University, has been appointed by the National Research Council a member of its central petroleum committee.

SIR GILBERT WALKER was reelected president of the Royal Meteorological Society at the annual meeting held on January 19.

DR. F. W. LINDHOLM has been appointed as successor to Professor C. Dorno to the directorship of the Physical-Meteorological Institute at Davos, Switzerland.

BEVERLY L. CLARKE has resigned his National Research Fellowship at Stanford University and is now research chemist with the Bell Telephone Laboratories, Inc., New York.

PROFESSOR KARL T. COMPTON, who has been on sabbatical leave from the physics department of Princeton University, has returned and resumes his work at the opening of the second term. Professor Compton has recently lectured at the Universities of Göttingen, London, Bristol and Cambridge on "Recent Researches in the Field of Ionized Gases."

PROFESSOR W. D. CAIRNS, secretary-treasurer of the Mathematical Association, is spending the year in California, on leave of absence from Oberlin College. He will be at Berkeley until early in May and then at the University of California at Los Angeles until early in August. The association business is being carried on by the assistant secretary, Professor C. H. Yeaton, at Oberlin College.

AMONG those who have been granted leave of absence for the second term at Cornell University are Professor Alvin C. Beal, who will spend several months in Europe in informal study of botanical gardens, parks and landscape gardening. Professor Samuel N. Spring will sail to observe forest conditions in Italy, France and Germany. Professor Eugene D. Montillon will study landscape architecture in France, Italy and England.

DR. M. J. ZIGLER, assistant professor of psychology at Wellesley College, will teach at the University of California, Southern branch, in the summer session of 1927.

DR. H. G. MCMILLAN, of the U. S. Department of Agriculture, located at the field station at Greeley, Colorado, is now at the Boyce Thompson Institute and will study the effect of ultra-violet light on potato plants and on the symptoms of diseased potato plants.

PROFESSOR WILLIAM E. HOFFMANN, head of the biology department of Lingnan University, Canton, China, represented the university and South China at the third Pan-Pacific Science Congress recently held in Tokyo, where he gave papers on entomology and parasitology.

M. GEORGES CLAUDE, of Paris, member of the Paris Academy of Sciences, gave a lecture under the auspices of the schools of mines, engineering and chemistry of Columbia University on January 11 entitled "Scientific and Industrial Researches."

DR. ABRAM T. JOFFE, director of the Röntgen laboratory and professor of physics in the Polytechnical Institute at Leningrad, spoke on the evenings of January 26, 27 and 28 before the physics department of the University of Pittsburgh and the Physical Society of Pittsburgh on "The Physical Deformation of Crystals," "The Passage of Electric Currents through Dielectrics" and "The Breakdown of Dielectrics."

BENJAMIN H. HUNNICUTT, dean of Escola Agricola de Lavras, Brazil, will give lectures in American agricultural schools and colleges from January through June on agricultural education in Brazil and general agricultural conditions in that country.

DR. ARTHUR HAAS, professor of physics at the University of Vienna, will speak before the Philosophical Society of Washington on February 17 on "The Atom as a Source of Energy."

PROFESSOR HENRI FREDERICQ, director of the institute of physiology at the University of Liége, Belgium, gave a series of lectures at the University of California on February 14, 15 and 16.

THE seventh postgraduate lecture of the faculty of medicine of Queen's University, Kingston, Ontario, was delivered on February 4 by Professor C. C. Macklin, of the University of Western Ontario, London, on "Modern Views on the Structure and Function of the Bronchial Tree."

DR. GEORGE GRANT MACCURDY, of Yale University, completed on February 4 a lecture tour of four weeks. He spoke twice at the University of Illinois, twice for the Davenport Public Museum, and once each for the Surgical Club of Omaha, the University of Iowa, the University of Michigan, the Toledo Art

Museum, the University of Buffalo and the Academy of Sciences of Warren, Pa. Dr. MacCurdy's lectures were on prehistoric archeology and dealt largely with the latest discoveries as well as with the work of the American School of Prehistoric Research, of which he is director.

DR. H. B. WILLIAMS, professor of physiology in the College of Physicians and Surgeons, Columbia University, will lecture at the Franklin Institute on February 24, on "Physical Instruments in Medical Service."

DR. LELAND O. HOWARD, chief of the U. S. Bureau of Entomology, spoke at Cornell University on January 27, on "Fifty Years of Economic Entomology."

DR. MARTIN H. FISCHER, professor of physiology at the University of Cincinnati, presented the annual N. W. Jones lectures under the auspices of the University of Oregon Medical School on January 12 and 13. Dr. Fischer's subject was "The Constitution of Living Matter and Its Significance in Some Problems of Physiology, Pathology and Medicine."

DR. KNIGHT DUNLAP, professor of psychology at the Johns Hopkins University, will deliver two lectures before the faculty and student body of West Virginia University on February 18.

DR. F. W. O'CONNOR, of the division of Medical Education, Rockefeller Foundation, gave a lecture on "Filariasis" on February 4, at the Harvard Medical School.

DR. A. V. KIDDER, chairman of the division of anthropology and psychology, National Research Council, is to address a joint meeting of the Anthropological Society of Washington and the Washington Academy of Sciences in the Cosmos Club, on February 24. His subject will be "Prehistoric Cliff-dwellers of Arizona and their Predecessors."

ON November 26 a memorial window to John Tradescant, the younger, was unveiled in the Ashmolean Museum of the University of Oxford. This museum, said to be the oldest in the Anglo-Saxon world, and based largely on the collections of the two John Tradescants, father and son, came to the university as a gift from Elias Ashmole, friend and heir of the Tradescants. The new memorial window in Oxford is the gift of the garden clubs of Virginia.

MISS CAROLINE L. HUNT, member of the scientific staff of the U. S. Bureau of Home Economics, died on January 27.

W. M. CHAUVENET, British consulting chemist and mining engineer, known for his work on the chemistry of ores and structural and mining geology, has died, aged seventy-one years.

DR. KARL HELL, emeritus professor of general chemistry at the Technische Hochschule in Stuttgart, died on December 11, aged seventy-seven years.

A BILL aimed at abolishing the teaching of the theory of evolution in the public schools of New Hampshire has been rejected, the committee on education of the House of Representatives voting that it was "inexpedient to legislate on the question."

REPRESENTATIVE L. O. RICHARDSON, of Adams County, introduced in the North Dakota House on February 5 a bill to bar from the schools any doctrine that teaches that man is of other than direct divine origin. Violation of the act would be termed a misdemeanor. It would provide a fine of not less than $25 or more than $100 for each offense.

THE Rotenberry anti-evolution bill, which would prohibit the teaching of evolution in tax-supported schools of Arkansas, has been rejected by the State Legislature. The senate voted on February 10 to table the bill, which was passed by the house at a session the day before.

THE *Vienna Zentralanstalt for Meteorology and Geophysics,* which was founded in 1851 at the instance of the Vienna Academy of Sciences, has reached its seventy-fifth anniversary. At the suggestion of the director, the late Dr. F. M. Exner, the academy celebrated the event by issuing a *Festschrift* dedicated to the institute; the volume, of about 200 pages, contains thirteen papers by Austrian and German geophysicists.

THE centenary of the birth of Lord Lister falls on April 5, 1927, and a committee has been formed to organize a celebration in London. At the suggestion of the Royal College of Physicians of London, the Royal College of Surgeons of England and the Royal Society of Medicine, the initiative was taken by the Royal Society, which is acting as a coordinating center. The celebrations will take place on Wednesday and Thursday, April 6 and 7. They will include a reception of delegates and the delivery of short addresses by some of them, a commemorative service in Westminster Abbey, a reception at the Royal College of Surgeons, a conversazione at the house of the Royal Society, a dinner with the Merchant Taylors Company in its hall and the delivery of discourses on Lister as physiologist, pathologist and surgeon.

THE University of Louvain, Belgium, will celebrate its five hundredth anniversary with formal ceremonies on June 28 and 29. Invitations have been received by officials of American universities and academies to take part and it is probable that delegations will be sent from several schools in the United States and Canada.

AN additional $155,500 for the U. S. Bureau of Mines would be included in the second deficiency appropriation bill under an amendment by Senator Oddie, of Nevada. The sum would be distributed as follows: Mineral mining investigation, $25,000; economies of the mineral industry, $40,000; operation of mine rescue cars and stations, $55,500, and investigation of mine accidents, $35,000.

UNDER a bill introduced on February 4 by Senator Neely, of West Virginia, a reward of $5,000,000 for the first person to discover a real cure for cancer would be paid by the federal government.

PROVISION for cooperation by the Smithsonian Institution with state, educational and scientific organizations in the United States for continuing ethnological researches among the American Indians, and the preservation of archeological remains, would be made in a bill introduced in the House of Representatives by Mr. Byrns, of Tennessee. The bill would authorize an appropriation of $20,000, to be expended for this purpose.

CANCELLATION of the assessment of duty on certain scientific apparatus imported by the Smithsonian Institution, amounting to $658.75, and the admittance of all further importations duty free would be authorized in a bill (House Bill No. 16737) introduced by Representative Newton, of Minneapolis, Minn.

DR. G. A. TALBERT, head of the department of physiology in the medical school of the University of North Dakota, has been given a grant of $300 for the extending of his research on the simultaneous study of the constituents that are common to the sweat, urine and the blood. The fund was appropriated by the American Medical Association for scientific research.

DR. R. A. F. PENROSE, JR., has given $500 for the support of the *Journal of Geology*, thus enabling the continuation of the improvements which were inaugurated by former gifts of Dr. Penrose.

A FOUNDATION for scientific research in mental hygiene and the treatment of problems of delinquency and criminology is provided for in the will of the late Dr. William F. Becker, of Milwaukee, which was filed in probate court. The estate is valued at $100,000.

THE London Hospital has received from Mr. Bernhard Baron, British tobacco manufacturer, a gift of £25,000 for the endowment of the Pathological Institute bearing his name, towards the cost of which he has already given £10,000.

DR. WM. SCHAUS, honorary assistant curator, division of insects, of the U. S. National Museum, has recently purchased and donated to the museum a collection of moths from Bolivia containing about 10,000 specimens. This is a large and important addition to the collection of South American moths, which is believed to be the largest in the world.

MRS. ROBERT W. WILLSON has sent to the Harvard College Library, in fulfillment of Professor Willson's wishes, 130 of the rarer volumes from his collection of works on astronomy.

INITIAL arrangements are being made for the repair of the *Carnegie* during 1927 in accordance with the appropriation made by the board of trustees of the Carnegie Institution of Washington on December 10, 1926, for the rehabilitation of that vessel, which must precede the three-years' cruise to begin in 1928.

THE will of the late Dr. Hamilton F. Biggar, Cleveland, includes a gift of $100,000 to the Cleveland Foundation, three fourths of the income from which is to be used for advancing the science of medicine and $5,000 to the Cleveland Medical Library Association.

THE Altman Foundation has donated $10,000 for the general work of the New York Academy of Medicine; an anonymous donor has promised a gift of $10,000 a year for five years, and a third $10,000 has been promised provided $300,000 for library endowment is raised before July 1.

CONTRACTS have been signed for the immediate construction of an agricultural engineering building at the Davis branch of the College of Agriculture of the University of California. The total cost is to be approximately $140,000, of which $125,000 was specifically provided for at the last legislature.

THE State Department of Conservation of Massachusetts has announced that Miss Susan Minns, of Boston, has made a gift to the Commonwealth of a tract known as Little Wachusett Mountain, Princeton, containing 127 acres, to be a wild life sanctuary forever. The gift was accepted by Governor Fuller and the executive council at their meeting on January 19.

A GIFT of £74,000 to Edinburgh University has been made by the International Education Board. This gift will be applied as a contribution to the cost of a new department of zoology, which is to be created at the King's buildings of the university, in the Craigsmillar district of the city. Of the total sum £30,000 is for the buildings, £10,000 for the equipment and £26,000 for endowment.

A DONOR who desires to remain anonymous has offered the University of London the sum of £10,000 towards the establishment of a chair of dietetics. Subject to certain conditions, the offer of Mr. J. G.

Wilson to present to the university a 24-inch reflector telescope has been accepted. Lady Godlee is giving a sum of money, to be held in trust for University College and University College Hospital Medical School, to found a Rickman Godlee Lectureship in memory of her husband, the late Sir Rickman J. Godlee. The managing director of the Vultex Products, Ltd., is to give a sum of money for three years for lectures on colloidal chemistry.

ACCORDING to the *United States Daily* the establishment of a national institute of health is proposed in a bill introduced in congress by Representative Kindred, of Astoria, New York. The measure would also authorize increased appropriations for the Hygienic Laboratory and proposes that the government accept donations for use in ascertaining the cause, prevention and cure of disease affecting human beings. An appropriation of $1,000,000 is asked to establish the proposed institute and $200,000 a year for five years to construct new and enlarged quarters for the Hygienic Laboratory.

PRELIMINARY sketches for the new six-story building for the U. S. Department of Agriculture have been submitted to Assistant Secretary R. W. Dunlap by the treasury department, according to the *U. S. Daily*. The building will be erected on the square between B and C Streets, and Thirteenth Street and Linworth Place, southwest, in Washington, D. C., at an estimated cost of $650,000 for the site, and $2,500,000 for the construction work. Two years will be required to complete the structure. During the first year, the entire ground floor will be completed at a cost of $550,000. During the second year the remaining floors will be erected. The total floor space will be 350,000 square feet.

THE American Society of Civil Engineers has awarded its Croes medal to Clarence S. Jarvis, of the United States Bureau of Public Roads; the Thomas Fitch Rowland prize to Nicholas S. Hill, Jr., consulting engineer of New York City; the James Laurie prize to Lewis A. Perry, construction engineer of the Longview Company, Longview, Wash.; the Arthur M. Wellington prize to Col. Charles W. Kutz, of the Corps of Engineers, United States Army, and the Collingwood prize for juniors to Cecil Vivian von Abo, of Johannesburgh, South Africa, chief civil engineer of the South African railways and harbors. These awards were for papers on technical subjects contributed to the society.

FROM a loan fund of £10,000,000 available for the development of the British East African colonies and dependencies, the use of £4,000 has been recommended by an allotment committee for the Amani Institute for Agricultural Research, according to the *Experiment Station Record*. It is expected that this institute, originally established in Tanganyika Territory under German auspices, will be developed as a center of scientific agricultural research for the region and also as a means of promoting tropical economic development.

UNIVERSITY AND EDUCATIONAL NOTES

ANNOUNCEMENT has been made of gifts of $100,000 from Cyrus H. K. Curtis, Philadelphia publisher, and $62,000 from the family of Dr. Charles E. Beury, president of Temple University, to the "greater Temple University" fund. Donations from all sources now aggregate $750,000.

GIFTS have been announced of $10,000 from Miss Helen Rand and $5,000 from the Jackson Johnson Shoe Company to Vanderbilt University.

To meet the growing demands of the free classes in engineering, Cooper Union, New York City, is installing equipment costing $40,000. Additions to the hydraulic laboratory aggregate $10,000, and when completed the present capacity will be doubled at a total outlay of $25,000. Similar enlargements of the mechanical engineering laboratories are planned.

PROFESSOR O. H. RECHARD has been made head of the department of mathematics at the University of Wyoming.

DR. C. M. MACKALL has been promoted to be head of the department of chemistry at George Washington University.

DR. O. C. MAGISTAD, soil chemist for the United Fruit Company, stationed at Tela, Honduras, has been appointed associate professor of agricultural chemistry in the University of Arizona and associate chemist in the Experiment Station.

DR. IRA L. BALDWIN has been appointed to the staff of the department of agricultural bacteriology at the University of Wisconsin.

MISS OLGA H. M. GLOY, who for the past two years has held a traveling fellowship from the International Education Board, has completed her work for the Ph.D. degree in the department of chemistry, Columbia University, and has been appointed lecturer in chemistry and nutrition in the University of Otago, New Zealand.

A. G. TANSLEY, lecturer in botany in the University of Cambridge, has been appointed to succeed Sir Frederick Keeble as Sherardian professor of botany at the University of Oxford.

PROFESSOR P. KOEBE, of the University of Jena, has been appointed professor of mathematics at the University of Leipzig.

DISCUSSION AND CORRESPONDENCE

BABYLONIAN DISCOVERY OF THE PRECESSION OF THE EQUINOXES

RECENTLY it has been shown[1] that the slow motion of the equinoctial points on the ecliptic, called the precession of the equinoxes, was first discovered before the time of Hipparchus, by a Babylonian astronomer *Kidinnu* (sometimes written *Kidenas* or *Cidenas*), who directed an astronomical school at Sippra, on the Euphrates, about 343 B. C. This Babylonian achievement had been suspected for some years, but no definite conclusion had been reached, because of uncertainties relating to the interpretation of astronomical records.[2] The final settlement of this question has become possible by the examination of some new Babylonian tables.

The fact that the astronomer *Naburiannu* (about 508 B. C.) fixed the equinoctial point at 10°, and Kidinnu, about a century and a half later, at 8°, the zero point on the ecliptic being interpreted as the same in both cases, shows that Kidinnu had a knowledge of the precession of the equinoxes. A study of tables indicates that from that time on, in the ephemerides following the system of Kidinnu, the zero point on the ecliptic was shifted from time to time, to enable astronomers to retain the same angular value for the beginning of the autumnal equinoctial years. This again implies a knowledge of precession. A table (VAT 7821) prepared not later than 186 B. C., and based on the Kidinnu system, gives solar longitudes from day to day, differing by 59′9″, an amount in excess of the true average value of 59′8″9‴.6 for a sidereal year, which was estimated by Kidinnu to be $365^{d}6^{h}13^{m}43^{s}$. This excess was corrected in the table by taking on a certain day 56′9″ in place of 59′9″. Thus the computer of the table took the average daily velocity of 59′9″ to yield in the course of one year, not exactly 360°, but an additional 3′. Dividing 360°3′ by 59′9″, and allowing liberally for certain possible sources of error, Schnabel concludes that the year considered by the computer could not have exceeded $365^{d}5^{h}30^{m}$. The modern value for the equinoctial solar year is $365°5^{h}48^{m}45^{s}$. Thus the Kidinnu astronomy had two years, the sidereal and the equinoctial. Kidinnu deserves to be ranked among the greatest astronomers of ancient times.

FLORIAN CAJORI

UNIVERSITY OF CALIFORNIA

[1] Paul Schnabel, "Kidenas, Hipparch und die Entdeckung der Präzession," *Zeitschrift für Assyriologie*, N.S., Vol. 3, April, 1926, p. 1–60.

[2] F. X. Kugler, "Sternkunde und Sterndienst in Babel," II Buch, II Teil, 2 Heft, 1924, Anhang II.

PUBLICATION BY PHOTOGRAPHY

IN connection with Professor Albrecht's article in SCIENCE for December 31, 1926, on "Publication by Photographic Reproduction of Typewriting," it should be noted that the Coast and Geodetic Survey has been using a similar method for some of its publications since 1923.

Attention was called to the possibility of using such a method by a publication of the Topographic Surveys Branch of the Department of the Interior of Canada, "Magnetic Observations in Western Canada," which appeared in 1921. In it the tabular matter, about 270 pages, was all reproduced photographically from typewritten sheets.

The advantages of such a method were recognized at once, not only the great saving in cost, but also the elimination of the tedious operation of proofreading a mass of figures and the inherent danger of errors being overlooked even by experienced readers, and steps were taken to make use of it where possible. The publications giving the results of observations at the magnetic observatories of the bureau consist largely of tables of uniform size and are, therefore, well adapted to photographic reproduction, and the method was given its first trial with them.

The principal tables give for each hour of each day of the year the values of declination, horizontal intensity and vertical intensity, as well as daily maximum and minimum values and daily and monthly means. These quantities are tabulated by months on suitable forms by means of a specially designed cross tabulating machine, the tabulation being made as the quantities are computed. A carbon copy is made at the same time, and this serves as the copy for photographic reproduction, after such changes have been made as result from the revision of the computation. With care in using fresh carbon paper there is no difficulty in securing a good reproduction even when the reduction in size is considerable.

The method is being used successfully in the publication of the quarterly Seismological Reports of the bureau, the issue of which began in 1926. In this case the copy for reproduction is prepared by typewriter, either with or without carbon paper backing.

D. L. HAZARD

COAST AND GEODETIC SURVEY,
WASHINGTON, D. C.

REFERRING to the letter by Dr. Albrecht regarding the advantages of photographic reproduction in publishing, I should like to add my testimony to the excellence of the method for all uses, but especially for tabular matter. The American Jersey Cattle Club has for several years been publishing its tables of production by the animals of the breed it records by this method, and the results are really not inferior to

the ordinary type, though having some of the imperfections that Dr. Albrecht notes. I can easily understand the cheapening in cost he suggests.

Recently I have received a book on this breed, containing considerable tabular matter, but mostly straight reading, made by this process, double spaced between the lines, type of the normal size of the typewriter, printed on one side of the sheet only, which is really easier on the eyes than the ordinary print, excelling even the admirable type used in SCIENCE in that respect.

I thoroughly agree with Dr. Albrecht in thinking that this method, particularly if improved as he suggests, might help to solve the financial problems that often present themselves to the impecunious research man who wants to let other people know what he has been doing.

And while we are about it, why not follow the suggestion of Dr. Metcalf on the same page, and adopt a character to convey the sound of "th"? I would suggest that the adoption of the crossed "h" which he mentions might lead to the same sort of confusion that some of us have experienced in reading the books of the eighteenth century in which the long "s" was used, and the difficulty in separating it from an "f." Why not take one of the letters from other languages, as the Greek θ?

LUCIUS P. BROWN

SPRING HILL, TENNESSEE

IN reference to the suggestions of Mr. Albrecht in regard to photographic reproductions of typewriting, I, some years ago, prepared a special text in physics for freshmen. I was unable to have it published in the usual way because the price of the book to the student would have to be so great that it seemed unreasonable. I then wrote the whole text on the typewriter, attached cuts in their place on the page and arranged with a firm in Cincinnati to photograph each page and make zinc etchings. This they did for $293.00. These were then sent to the Reformatory at Mansfield, Ohio, where the books were printed and bound for $150.00—500 copies. This made a total of $443.00 and the books could then be sold to the students at $1.25, which not only met all expenses but cleared a small margin for the department.

J. A. CULLER

MIAMI UNIVERSITY

EXPLORATION OF THE ETOWAH MOUNDS

THE department of archeology, Phillips Academy, Andover, Mass., has carried on two seasons' exploration at a large village site and mound group in northern Georgia. About one hundred stone graves were discovered which contained some engraved shells, various ornaments, pottery vessels and some engraved copper plates. The eminent authority on Mexican cultures, Mrs. Zelia Nuttall, examined the collection at Andover and suggested several lines of comparison between certain of the human figures and those observed among Toltec and Mayan remains. It is not claimed that any connection exists, but some of the comparisons are exceedingly striking.

Two complete sarcophagi were shipped to the Andover museum, set up, filled with Georgia earth and the skeletons and objects placed in natural position. Five such graves were shipped to other museums and have attracted considerable attention.

Any museum director or curator who wishes one of these graves and its contents can correspond with me at Cartersville, Georgia.

WARREN K. MOOREHEAD

METAPSYCHICS

IN my "Zoology" (1922), page 536, I have given an explanation of the term Metapsychics, which may perhaps later come into more general use. It may be worth while to record the history of this term, before it is forgotten. I published it in *The Dial* (Chicago) of February 1, 1905, page 86, with a definition. In the *Daily Graphic* (London) of February 9, 1905, page 7, I read that quite independently Professor Richet had proposed the same term at a meeting of the Psychical Society. If there is an earlier publication of the word, I have not found it.

T. D. A. COCKERELL

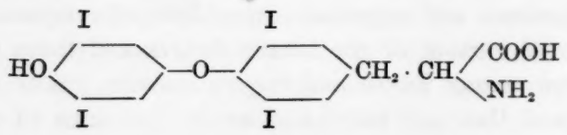
QUOTATIONS

THYROXINE

RECENTLY the Chemical Society resolved to award the Edward Frank Harrison Prize for 1926 to Dr. C. R. Harington, of University College Hospital. The achievement which has earned this tribute from the colleagues of Dr. Harington has been the synthesis in the laboratory of the active principle of the thyroid gland—the substance thyroxine.

It was only in June of the present year that those who follow the literature of chemistry learnt of the progress of his labors, and discovered Dr. Harington on the very threshold of a complete success. Two papers under his name appeared at that time in the *Biochemical Journal*. The first described a greatly improved method for the separation from thyroid tissue of the hormone in a chemically pure state—a method, moreover, which was not found wanting when pursued in an industrial laboratory. The second paper proceeded to the chemical analysis of the pure

substance, and here the classical methods of degradation and synthesis joined in the demonstration that thyroxine was to be represented by the chemical structure:



In one particular only was this formula uncertain. The position of the four iodine atoms could not be definitely affirmed. It had been possible to remove these from the molecule of the natural product. It had been possible by two independent methods to synthesize in the laboratory the iodine-free substance by a series of reactions accurately defining its structure. It had not then been found possible to introduce into the synthetic substance those four atoms of iodine which, in their proper orientation, would create the molecule which is thyroxine.

In a joint communication by Dr. Harington and Professor G. Barger to the December meeting of the Biochemical Society, the final solution of the problem was unfolded. Commencing with hydroquinone and tri-iodo-nitro-benzene — materials which inspired a press report to describe, a little optimistically, the synthesis of thyroxine from "coal tar products and iodine"—a series of classical organic reactions were adapted with masterly tidiness to the issue of a product of the above chemical structure. The substance was chemically indistinguishable from that isolated from thyroid glands. The chemical chapter is complete, the biological story opens. Use was made of the now well established quantitative effect of the hormone on the basal metabolic rate. Two myxoedematous patients were chosen. Their basal rates were respectively 32 and 45 per cent. below normal. Intravenous injection of the synthetic substance was spread over six days to a total dose of 14 mg, and the basal metabolic rates rose, in the first case to 6 per cent. short of normal, and in the second to 3 per cent. above normal. There occurred a coincident fall in body weight and increase in the pulse rate. Such activity was quantitatively as great as that given by natural thyroxine. Physiologically the two substances were indistinguishable. The structure of thyroxine requires the existence of two stereoisomeric forms, and we may suspect that the thyroid gland, by virtue of that elusive asymmetry of vital activities, synthesizes and employs but one of these isomers. That the substance obtained from the gland is the racemic mixture is due to the inevitable racemization which accompanies the process of separation, and it is not improbable that a resolution of thyroxine into its active forms will show that physiological activity is restricted to one only of these. This form should then be twice as active as the materials yet tested. The methods of physiology must now take the field. With thyroxine to hand there is available a means for the quantitative study of the rôle of the hormone and the function of the gland.

The committee which resolved to award the Harrison prize to Dr. Harington comprised the presidents of the Chemical Society, the Institute of Chemistry, the Society of Chemical Industry and the Pharmaceutical Society. Thus have the theoretical and applied interests of a science united to acknowledge the common benefit in a great academic adventure.—*The British Medical Journal.*

SCIENTIFIC BOOKS

Studies of the Variation, Distribution and Evolution of the Genus Partula; the Species inhabiting Tahiti. By HENRY EDWARD CRAMPTON, Ph.D., professor of zoology, Barnard College, Columbia University; curator of invertebrate zoology, American Museum of Natural History. The Carnegie Institution of Washington, 1916. 307 pages quarto. 33 plates.

ONE of the most important contributions to our knowledge of animal evolution, perhaps the most important yet published in the twentieth century, is Dr. Crampton's "Study of *Partula,*" a genus of land snails found in the forests of islands of the South Seas. The central problem of evolution is, as indicated by Darwin, that of the origin of species. There exist on our earth a prodigious number of kinds of animals and plants. These are variously interrelated, and their relations are shown in their structure and development and are connected with their distribution and that of their ancestors in space and time. The features of their relations and the causes of their diverging progression constitute the factors in evolution. The determination of these factors in detail is to science vastly more important than the fate of any or all philosophies of evolution. And the study of these facts is essentially, as Darwin, Wallace, Wagner, Ortmann, Kerr and others have shown, an out-of-door subject, on which not much light can be thrown by closet studies. Studies in greenhouses or breeding-pens have been devoted mainly to problems of heredity, a matter of the greatest importance to biology, but not necessarily illuminating the problem of origin of species.

Even the meaning of species has been confused through indoor studies. A fairly inclusive definition is that *a species is a definable kind of animal or plant which has run the gauntlet of life and which has endured.* The imitation species of the laboratory have arisen through much the same elements, yet they have

not been tested for endurance in the gauntlet of life. For the most part they could not endure in the open because their selection is not based on fitness for survival, and because, without segregation, they would soon be lost by interbreeding with the prepotent mass. As is the case with actual species, the "creations" of the breeder begin with individual variation, this continued through heredity, restricted by selection and kept apart by segregation. In nature, species originate in essentially the same way, except the period of testing for endurance is enormously prolonged. Selection is "natural" and the segregation is a feature of geographical distribution. Where the breeder of flies segregates in bottles, nature uses mountains, deserts, seas, climates and food conditions, in developing her species. But every one of these rests on all of at least four factors or conditions, two internal, variation and heredity; two external, selection and segregation. In every species results of each of these traits are shown. Hence they are factors in evolution. By many recent writers, these external factors, especially the last, are overlooked or slurred, as though divergent change could take place *in vacuo* by the operation of a "law of evolution." The dictum of Wagner, *"Ohne Isolirung keine Arten,"* holds good, for the final segregation of all forms is associated with "räumliche Sonderung" or separation in space from the main stock. Precisely the same thing occurs with our temporary species or "creations," but these are too recent to be tested through "running the gauntlet of life" or the prevention of mass breeding.

The land snails called *Partula* consist of many species living on trees, the individuals relatively stationary and closely limited by local conditions. Dr. Crampton has undertaken the detailed study of these snails in all the minute features which concern their life and distribution. The "headquarters of the group" are in the Society Islands (Tahiti, Raiatea), though species are widely scattered elsewhere on various other island groups. None are found in the Hawaiian Islands, where their place is taken by a parallel group, the *Achatinellidæ,* already famous through the work of the late Dr. John T. Gulick.

Dr. Crampton has made four journeys to Tahiti and the other islands of the South Seas. In these trips more than 80,000 specimens, taken from two hundred different valleys, were obtained and studied, covering many different species and subspecies. The work had three purposes: first, the study of results of "isolation and environmental influences as conditions or factors of biological differentiation. These have been variously estimated in the writings of naturalists from Darwin, Wagner, Murray, Wallace, Gulick and Romanes to Allen, Jordan, Ortmann and others . . . who have accorded to the 'environment' almost all degrees of efficiency, from omnipotence to impotence."

The second purpose was to continue Dr. Albert G. Mayer's work on inheritance of shell and color characteristics; the third to bring back living material for studies in selective breeding of pure and hybrid strains. But the species must themselves be known before much advance in this line is possible. It was found that each island, even in the same group, had its own species of *Partula* which (except in rare cases) occur nowhere else. The study of these cases throws much light on dispersal and migration as well as on certain matters of geology. It was found that some species range widely over a whole island and others are restricted to a few valleys, or even to one. These conditions give rise to numerous subspecies or varieties. In connection with the singularly accurate observations of *Partula* by Andrew Garrett in the sixties, it has been possible to trace the relative age of several species. Mutations, or wide individual variations, occur frequently, "so that it can not be regarded as a unique feature." The effect of environment in originating new species is negligible. Dr. Crampton regards isolation as a "condition" rather than a "factor" in species forming. This seems a matter of words. Barriers act as obstructions behind which new species form, thus becoming a negative factor. Dr. Crampton finds in the distribution of *Partula* evidence of large subsidence in the Pacific Area, causing disconnection among islands and mountain peaks, with parallel effects on the snails they bear.

All the species and subspecies mentioned in this monograph are beautifully figured in color. There are also numerous maps and photographs illustrating the wild and picturesque scenery of the Society Islands.

DAVID STARR JORDAN
STANFORD UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE LABORATORY QUARTZ MERCURY LAMP

A SIMPLE and efficient quartz mercury lamp, with electrodes not sealed in, and easily constructed in the laboratory for from two and a half to five dollars, is shown in Fig. 1.

A is a quartz tube of 0.6–1.0 cm bore and 5–8 cm long. B and B′ are quartz capillary tubes of 1 to 2 mm bore and approximately 10 cm long, bent at C and C′ nearly perpendicular to A. The bend CD is approximately 2 cm long. Both capillary legs are

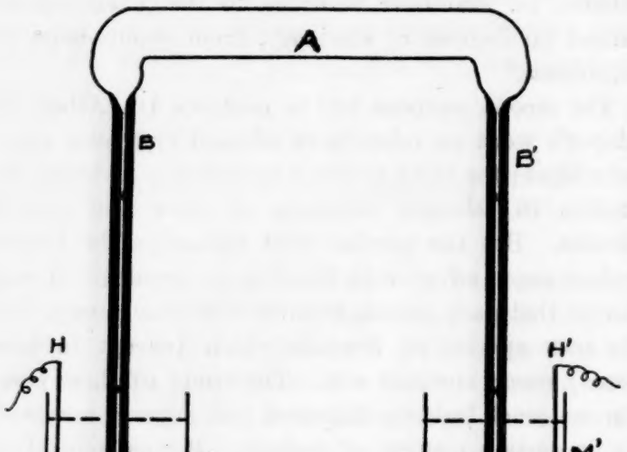


Fig. 1

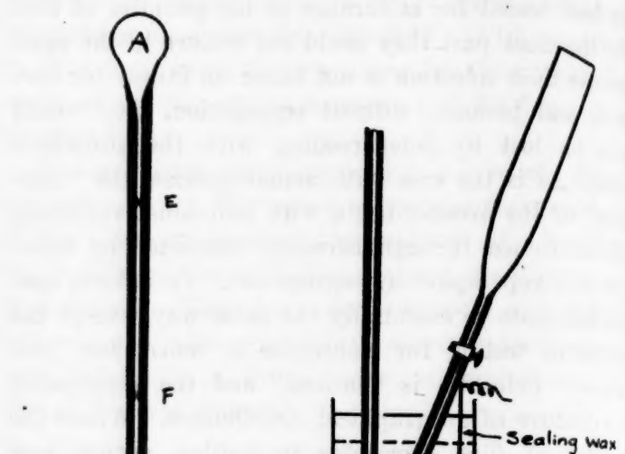


Fig. 2

constricted at two or three points, which serve to damp the oscillation of the arc.

The lamp stands in small beakers or cups M and M′, filled with mercury and provided with iron wire electrodes H and H′.

In order to fill the lamp with mercury, the ends of the legs are dipped in the mercury pools, while the portion A is tilted and lowered as far as possible. The portion A is then heated to expel a part of the air from the apparatus. As the tube cools, mercury flows down into A, which is now boiled to drive all the air and moisture out and to completely fill the lamp with mercury. The lamp, again brought to the upright position as shown in the figure, is ready to be operated.

To start the arc, a point of A is heated until the mercury in the tube boils and the arc starts. It becomes perfectly steady within five minutes.

A lamp was constructed with the following dimensions:

A	0.6 cm. inner diameter
	1.3 cm. outer diameter
	7.0 cm. long
B	0.2 cm. inner diameter
	0.6 cm. outer diameter
	10.0 cm. long
CD	2.0 cm. long

It was operated with 130 volts at the generator, through a 100-watt tungsten and a 20-watt carbon lamp in parallel and gave an extremely steady arc 4.5 cm long, the arc voltage being 78 volts and the current 0.7 amp. It has been in use nearly every day for over three months without causing any trouble. It has been operated for seventy-five hours continuously without a single readjustment. While the generator voltage varies between 120 and 150 volts, the potential drop across the arc varies from 67–110 volts, corresponding to 19–21.6 volt/cm gradient when the current is .65–.8 amp.

Another lamp of the same dimensions, except that A is of 0.7 cm outer diameter and 8.5 cm long, was constructed. Operated with 125 volts at the generator, this lamp gives an arc of 4 cm length, the arc voltage being 75 volts and the current 0.7 amp. With higher voltage, the tube A must be cooled by a strong air current. When fed with 150 volts, this lamp gives a very steady arc 7 cm long, the arc voltage being 100 volts and the current 1.2 amp. Air is blown through small holes along a tube against the entire length of the arc.

After the arc is run for from ten to fifteen hours, the mercury transferred to the negative pole may be brought back to the positive pole with a pipette.

This type of quartz lamp can be operated under various pressures by the simple modification shown in Fig. 2. A glass tube with stopcock is inserted in one of the mercury pools. With the stopcock open, it is partly filled with mercury. A thick layer of melted sealing wax is then poured over the mercury pools and allowed to cool. A mixture of water glass, silica and barium sulphate would probably be preferable. Constrictions on the legs of the lamp will be unnecessary to this modified form.

After the arc is started as above described and the desired length obtained, the stopcock may be closed and various currents and voltages applied. This lamp is successfully operated with generator voltages of 125 to 150 volts through a bank of lights.

With the stopcock open the arc voltage is 50 to 118 volts, corresponding to 18–20 volts/cm gradient, the current being .75–1.4 amp.

With the stopcock closed the arc voltage is 54 to 125 volts, corresponding to 23–30 volts/cm gradient, the current being 0.6–1.95 amp.

The advantages of the lamps described above are (1) simplicity of construction, (2) extremely low cost, (3) adjustable length of arc and (4) various pressures may be used.

The small quartz tubes can be blown very easily by means of an oxygen-gas blast burner, the gas being enriched by passing through casing head gasoline or petroleum ether.

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SPECIAL ARTICLES

SAP FLOW AND PRESSURE IN TREES

THE authors having been engaged in the study of movements of solutions in plants for several years arranged to collaborate in a series of experiments at the Desert Laboratory and at the Coastal Laboratory of the Carnegie Institution of Washington for a period of eight months in 1926. Professor Gilbert Smith joined us in some supplementary and anatomical studies for a few weeks. It seems advisable to present some of the results already obtained.

These support the theory of the upward movement of sap in trees in a cohesive column extending from the menisci in the walls of transpiring cells in leaves extending downward through dead wood cells and vessels and outward through the living cells of the root into the soil. The upward movement of water through such a system may continue at a diminished rate after the living cells at the upper and lower ends of the system are killed if the colloidal remains of the killed cells are not disturbed mechanically.

An examination of the assertions of Sir J. C. Bose that sap is pumped upward by pulsating action of living cortical cells has been made. Bose's claims as to the rate and mechanism of sap movements ignore well-established anatomical and mechanical facts, and are based upon imagined but impossible hydrostatic action of living cells. No single direct observation nor any measure of pulsatory action has ever been made, by Bose or any one else, yet his explanation of the ascent of sap is based on such an idea. It seems to be plainly evident to most beginners in botany that the drop of water applied to one smoothed end of a saturated branch is not identical with the drop appearing at the other end almost instantly, or that when water under pressure is turned into a hundred feet of filled garden hose the instantly resulting stream from the nozzle was made up of water that had traversed the length of the hose, yet Bose's estimates of sap-flow are based on preposterous assumptions that erection of flagging leaves is due to water passing from the base of stems to these organs at rates of 70 mm per second or as much as 70 meters per hour.[1]

Bose's conclusion that the wood serves as a reservoir from which living cells draw water and pump it by pulsating action not through wood, but from protoplast to protoplast at the rates given would imply transfer through two to four hundred living cells per second is too fantastic to be the subject of any serious comment.

To ascribe rhythmic variations in galvanometer readings connected with probes pushed into cortical layers[2] as due to hydrostatic pulsations is to throw aside all the safeguards of research. With Bose's suggestion that these pulsations may be the result of stimulation by friction of the roots with soil particles it is realized that the passage from pseudo-research to infantile fancies is an easy one. A sympathetic exposition of the Bose Institution and of the work of its director reprinted in *The Garland* (Calcutta) for May, 1926 (edited by S. M. Swaminathaiyer) includes the following passage: "For the mysteries of nature are probed in Sir Jagadish's institute not by study of libraries or by mechanical experiments, but primarily by communion with the unseen and the unknown. Inspiration, imagination, intuition, vision, this is an even more romantic touch."

The correctness of this characterization is attested by every page of Bose's book on the ascent of sap, which is utterly lacking in scientific significance. Such books appearing on the lists of scientific publications constitute a menace and danger to sound science.

Since the acceptance of Bose's work in America and since it has been widely proclaimed in the popular press of Great Britain, we are led to say that such recognition of Bose's work on ascent of sap and the nervous mechanism of plants has been confined to persons of non-scientific training, political propagandists and literary reviewers, whose capacity for judgment, motives and purposes may not be adequately discussed here.

Much attention has been given in our experiments of the past three years to the path of the upward movement of liquid in different types of woody stems and to the analysis of varying pressures which may be detected in the cortex, water-filled wood and gas mesh-work in the older wood. A comprehensive

[1] Bose, J. C. "The Physiology of the Ascent of Sap." London, 1923.

[2] This reaction has not been confirmed. See Dixon, H. H., "The Transpiration Stream," London, 1924.

presentation of earlier results was published in 1926.[3]

Positive or exudation pressures in latex systems and resin canals have been measured. Some positive pressures have also been found in bores driven into central or older wood which are ascribable to temperature expansions of gases. Pressures as great as 5 Atm. have been found in resin canals in pine trees, and of nearly one Atm. in other trees attributable to gas expansion in the heart wood.

These sources of positive pressure seem clearly separable from positive pressures ("root-pressures") which show on stumps of stems and of roots. For these no adequate explanation has yet been found.

The liquids used by us in tracing the movements of sap include toxic solutions of picric acid, 1 pct., which are carried along by the sap stream and diffuse into living cells; solutions of anhydrous sodium tellurite at 0.00007 to 0.00017 M which is reduced by protoplasm and gives a black precipitate not toxic at this concentration, and acid fuchsin 1–1000 in distilled water, the particles of which are so large that they may pass through microscopic openings such as the perforations in the membranes of pits in coniferous wood, and other openings left by the disintegration of plasmodesmen.

Strasburger's classical experiment of the movement of picric acid in a tree was repeated with the arroyo willow (*Salix lasiolepis*).

As a result it is concluded that conduction is strictly in the xylem and that the movement in this tract is of a different type and rate from that in the phloem. Experiments show that differences in age, amount and position of the wood affect its conducting capacity. Conduction of dyes is most rapid and to the greatest heights in tracheae with unblocked lumina, those containing tyloses, deposits of gum, or blocked with gas bubbles conducting feebly, if at all. In the willow practically all annual rings retain their capacity to conduct, but the individual elements of the xylem possesses unequal conducting capacities, the spring and summer wood not being concerned to the same extent. Conduction occurs mainly in the late summer wood of any annual ring near the terminal parenchyma. In this species tyloses develop very early and are present in all annual layers of wood, even in that of the current year's growth. Blocking of the vessels by tyloses occurs extensively in all layers except in the vessels of the late summer wood in which region conductivity is retained for years. Frequently certain later formed vessels of the summer wood do not abut upon medullary rays. As there is no wood parenchyma other than the terminal parenchyma, these vessels are not in contact with parenchymatous cells formed by the cambium. Therefore no tyloses can be formed in such vessels. Vessels of the spring and early summer wood, or the contrary, almost always lie adjacent to medullary rays, and most of these vessels are blocked by tyloses.

In the walnut, conduction is also mainly in the late summer wood, but not so sharply confined to this region as in the willow. Unlike the willow, all vessels are in contact with living parenchymatous cells, hence the possibility of the formation of tyloses in all vessels. All vessels of the spring wood usually become blocked by tyloses toward the end of the growing season, after which conduction occurs only through the unblocked vessels of the summer wood. However, these vessels of the summer wood of any annual layer develop tyloses and also become blocked, so that there is consequently no conduction through either spring or summer wood. The summer wood retains its conducting capacity for a period of four to six years, after which tyloses develop in the vessels of the summer wood and consequently there is no conduction through either spring or summer wood. Conduction is therefore confined to a certain number of superficial rings and there is no conduction through the interior heart-wood.

It appears that the presence of living cells in contact with the conducting elements of the xylem is a hindrance rather than an aid to conduction, as they may form tyloses and block the vessels. Furthermore, the conduction of a comparatively harmless dye in an untreated stem is not different in any essential particular from that in a trunk filled with picric acid. The existence of perforations in membranes of bordered pits of the wood of Monterey pine was demonstrated by pulling particles of Chinese ink, and particles of graphite from "aquadag," a lubricant made up in a watery suspension, by means of suction set up and maintained by a rotary air pump working in heavy oil, through sections of stems of the Monterey pine.

The pattern of the conductive tracts in the pine, walnut and willow have been made out. It has been found that the number of layers occupied by sap and the part of each layer serving as conduits is determined by perforations in pit-membranes, by tyloses and by apical connections with transpiratory systems in leaves.

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[3] MacDougal, D. T., "The Hydrostatic System of Trees." Publ. 373, Carnegie Inst. of Wash., 1926.